Figure 3 illustrates a prior art bulk acoustic wave resonator having a via-hole structure,

Figure 4 illustrates a prior art bulk acoustic wave resonator isolated from the substrate by an acoustic mirror structure,

Figure 5 illustrates a prior art stacked bulk acoustic wave resonator,

Figure 6 illustrates the laterally one-dimensional model of a resonator,

Figure 7 illustrates schematically typical dispersion relations $k(\omega)$,

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Figure ~~8~~ 8a-f illustrates schematically partial cross sections of various resonator structures according to the invention,

Figure 9 shows on Smith's chart a calculated electrical response of various resonator structures similar to that presented in Figure 8a,

Figure 10 shows schematically a bulk acoustic wave resonator structure according to a first preferred embodiment of the invention,

Figure 11 shows on Smith's chart a calculated electrical response of the resonator structure presented in Figure 10,

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Figure ~~12~~ 12a-d shows schematically top views of some resonators according to the invention,

Figure 13 shows schematically a resonator according to a second preferred embodiment of the invention,

Figure 14 shows schematically a resonator structure according to a third preferred embodiment of the invention,

Figure 15 shows on Smith's chart the measured electrical response of a resonator structure according to the third preferred embodiment of the invention,

Figure 16 illustrates the measured strength of spurious resonances in resonator structures having a frame-like zone formed by two partially overlapping layers,

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Figure ~~17~~ 17a-b illustrates schematically a resonator structure according to a fourth preferred embodiment of the invention, and

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Figure ~~1A~~ 18a-d illustrates resonators structure according to a fifth preferred embodiment of the invention.

Above in conjunction with the description of the prior art reference was made to Figures 1-5. The same reference numerals are used for corresponding parts in the figures.

The effect of the frame-like zone on the piezoelectrically generated vibrations of the resonator can be, according to current view, most straightforwardly sketched using a laterally one-dimensional model of a resonator. In this model, the resonator is assumed to be a plate, whose length in, for example, the *y*-direction is infinite, and whose dimensions in the *xz*-plane are finite. Figure 6 presents plates 610 and 620, whose length in *y*-direction is infinite. The lateral vibrations are, correspondingly, studied in one dimension, namely in the *x*-direction. If the material of the plate is elastically isotropic the equation for the displacement vector **d** of a sinusoidal acoustic wave is

$$-\rho\omega^2\mathbf{d} = (\lambda+\mu)\nabla(\nabla\cdot\mathbf{d}) + \mu\nabla^2\mathbf{d} \qquad (1)$$

where ρ is the density and λ and μ are the elastic Lame's constants of the plate material.

The Helmholtz' theorem states that the solution can be expressed as

$$\mathbf{d} = \nabla\varphi + \nabla\times\mathbf{A}$$

where φ is a scalar function and **A** is a vector function. The equations for the longitudinal wave φ and for the shear wave **A** are

$$-\omega^2\rho\varphi = (\lambda+2\mu)\nabla^2\varphi$$

$$-\omega^2\rho\mathbf{A} = \mu\nabla^2\mathbf{A}.$$

The solutions for φ and **A** are $\varphi = A_L\, e^{j\mathbf{k}\cdot\mathbf{r}}$ and $\mathbf{A} = \mathbf{A}_S\, e^{j\mathbf{k}\cdot\mathbf{r}}$, where A_L and A_S are amplitude constants, **r** is the position vector, **k** is the wave vector and j is the imaginary unit.

Thus there exist two types of waves with angular frequency ω as solutions to Equation 1. The displacement **d** is the sum of a displacement component $\mathbf{d}_L$ related to the longitudinal wave and a displacement component $\mathbf{d}_S$ related to the shear wave